WHY CHANGING THE WAY TO MEASURE THE RISK ?

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ABSTRACT

The SEVESO II Directive gives the rules to identify high risk potential establishments with the amount of hazardous substances handled and their operators have to produce safety reports. Although rules are well established to identify potential risk, there is no method to measure the risk level which takes into account safety devices and safety management systems implemented by operators.

In fact, the lack of rules to integrate the prevention made by operators has negative effects :

- Operators are not encouraged to increase the risk prevention,
- Risk decision-makers have no clear opinion of the real risk level,
- The risk expert's job is tricky because of the lack of method to identify reference scenarios.

Furthermore, the risk level is appreciated in fact throughout an effect distance. This way is too simple to give a pertinent enough risk assessment. In fact, risk evaluation should include other parameters to be more representative : the area concerned by the phenomenon, its kinetic, the ability to generate domino effects.

Because of all above reasons there is a need to define rules to identify scenarios integrating the prevention made by the operators and then to evaluate them by taking into account the characteristics of the phenomenon involved.

CONTEXT AND REQUIREMENTS OF THE COUNCIL DIRECTIVE 96/82/EC

The Council Directive 96/82/EC of 9 December 1996 on the control of major-accident hazards involving dangerous substances, known as SEVESO II Directive, aims at the prevention of major accidents and the limitation of their consequences for man and environment, with a view to ensure high levels of protection throughout the European Union in a consistent and effective way. It applies to industries that use a significant amount of materials that are hazardous to people and the environment. Operators of such industries must demonstrate that they have assessed the risks and are managing it, that they have a policy for the prevention of major accidents and a safety management system, and that finally they have adequate response plans in case of emergency.

Accordingly, a better management of hazards is necessary. Also tools have to be used to help the operators to carry out the risk analysis and to build a safety management system. Such tools have to be recognised by the Public Authorities and the decision-makers in charge of risk control. After reading the Directive, the objectives in terms of risk management are clearly laid down but the remaining question is : how to reach them ?

As the documents produced by the operators have to be demonstrative, it would be useful that the analysis led by the operators follows a recognised methodology. The multiplicity of methods for the evaluation of major accident hazards as a result of difference of cultures,

makes it difficult to propose a harmonised procedure. However, some aspects of the different approaches can be put in common such as scenario identification and gravity evaluation.

PERVERSE EFFECTS OF THE LACK OF ADEQUATE METHOD TO MEASURE THE RISK

Although rules are well established to identify risk potential on the base of the quantity of dangerous substances (Annexe I of the Council Directive 96/82/EC), there is no commonly recognised method to measure the risk level of units, which takes into account safety devices and safety management system implemented by operators.
In fact, the lack of rules to integrate the prevention made by operators has negative effects :

1. Risk prevention not encouraged

Often, after identification of the establishments covered by the Directive, its risk is perceived by the Authorities and the decision maker mostly throughout the use of safety distances taken from the safety report. For example, articles 11, 12 and 13 may all give rise to a concept of 'zones' around a SEVESO establishment linked to, respectively [2]:

- Emergency planning ;
- Land-use planning ;
- Information to the public on safety measures and behaviour in the event of an accident.

It follows that for the population and for some actors involved in risk management at a geographical scale, the risk level of an establishment is directly proportional to the safety distances or safety areas allocated for the above mentioned uses. Finally, the most commonly used risk level index is scaled in meters.
The perverse implication of such an implicit index is that operators are urged on restricting the consequence of the scenario by implementing protective devices like water curtains, detection systems connected with quick closing valves... On the other hand, prevention has no benefit on the effect of major accident scenarios because it does not reduce its consequences. That is why operators are not encouraged to improve the prevention. This statement must be also linked to the fact that the majority of the major accidents reported in the Community are the result of managerial and / or organisational shortcomings. Besides, it also must be noticed the new occurrence of so called 'post SEVESO accidents' which involved failure of safety devices [4], that suffered from non appropriate maintenance and testing.
To sum up, on the one hand, the Council Directive 96/82/CE asks efforts from the operators to demonstrate that they implemented a major-accident prevention policy and a safety management system, on the other hand, the uses and in particular the zoning established from these documents (safety report), do not urge an efficient prevention policy. The SEVESO Directive, viewed as a good example of 'goal-setting' legislation needs, in addition, the development of a methodology, first, in order to guide the choice of reference scenarios that have to be selected in function of their use (emergency plans, land-use planning, acceptance of siting new establishments). Second, a risk level evaluation that would take into account the prevention made by the operators would encourage them to invest in actions to improve the efficiency of the safety management.

2. No clear opinion of the real risk level

In the first part, it was demonstrated that the risk level of an establishment is perceived through the safety distance reserved around the plant for land-use planning or for emergency plans. But the quick analyse of major accidents, in comparison with the safety distances around industrial sites shows a great gap.

- Safety distances in case of toxic releases are widely beyond the limits of the establishment (often more than 1 or 2 km). However, except the accident at Bhopal in 1984, the accident reports only mention some injuries, sometime serious and within these limits [6, 7].
- On the contrary, safety distances in case of flammable releases are often inside or in the close neighbourhood of the establishment (300 to 500 m). However, the accidents reports often mention fatalities and serious injuries, futher away [6, 7].

Barnesville, USA	***June 1981***	Release during 25 minutes of 40-50 tons of anhydride ammonia from a storage	30 persons injured (8 seriously) some of them were drivers on a motoway nearby, who lost control of their vehicle or tried to run away on foot
Asfeld, Germany	***January 1990***	Rupture of a 25 mm pipe during the unloading of a chlorine rail tank car to a 50 tons storage	Inhabitants were in the vicinity of the plant : 120 persons sent to hospital and 5 persons seriously intoxicated
Flixborough, UK	***June 1974***	Leakage in 2 reactors caused the explosion of 40 to 50 tons of cyclohexan	28 fatalities , 89 injuries All construction destroyed within a radius of 600 m Windows broken within a radius of 13 km , big fragment at 6 km
Pasadena, USA	***October 1989***	Explosion of ethylene and isobutanol in a chemical unit producing polypropylene	23 fatalities , 124 injuries Plant completely destroyed Windows and walls damaged within a radius of 7 km

Example of accidents given in document [6]

In the case of 'tables of appropriate separation distances' use for instance in Sweden [2], it can be noticed that the greatest separation distances also are for toxic products.
This general trend demonstrates that the safety distances for toxic release seems to be overpredicted in comparison with the safety distances for flammable substances. This trend can be analysed both for consequence based approach and for risk based approach.

3. No consistent approaches

In fact, risk experts from all EU countries mostly agree with the major accident scenario. When asking different experts from European Countries about the definition of the scenario chosen and evaluated in the safety reports, the answers will not always be the same. In fact, there is no recognised definition of the major reasonable, credible or realistic scenario.
Generally in France, because of the French consequence based approach, the scenario chosen are such as BLEVE, total instantaneous loss of containment, instantaneous rupture of the largest pipeline leading to the highest mass flow, fire in the largest tank, explosion of the largest mass of explosive... [2, 3] However sometimes, the urban constraints of residential area development or new road constructions in the vicinity of existing establishments urge the company to reduce the safety distances. Then it is proposed to choose a more 'realistic' scenario than the previous one, by taking into account the efficiency of mitigation devices that already existed or that will be implemented. In fact, because of the lack of rules for identifying the scenario, the expert's job is tricky. He can't rely on an established method to put aside the major scenario and to choose other scenario characteristics.

Because of all above reasons there is a need to establish rules to identify scenarios integrating the prevention made by the operator and to propose a method for their evaluation. This evaluation will allow to properly measure the risk of a unit depending on the phenomenon involved.

A new method for risk evaluation

First, it is proposed to define a method giving rules for the identification of scenarios that take into account mitigation devices and risk prevention actions.

Then the evaluation of the scenario should consider more representative parameters than distances, and their evaluation should be calculated by integrating the effect area concerned with the phenomenon, its kinetic, its potential to generate domino effects...

1. Scenario identification

The objective is to identify major 'Reference Scenarios' regarding the analysis of accidents data bases like MARS [9] and taking into account the current practices (state of the art) contained in the lawful requirements with regard to conception, operation and control, and safety mitigation devices.

The reference scenario allows to find more realistic scenarios and to put aside some major scenarios, considering a unit operated today.

The Reference Scenario could be identified with an algorithm based on the labelling of the substances (Council Directive 67/548/EEC of 27 June 1967 on the approximation of the laws, regulations and administrative provisions relating to the classification, packaging and labelling of dangerous substances) and the conditions of use (pressure, temperature...). This scenario is mainly generated by external events (mechanic aggression, thermal aggression, earthquake...) or internal failure that can be identified by studying the process with a method like HAZOP pointing process parameter deviation (runaway reaction, overflowing...).

2. Scenario gravity evaluation

In the first paragraph, it has been demonstrated that the risk level is appreciated throughout effect distances. The objective of the gravity evaluation is to calculate a gravity index depending only on physical parameters that makes it possible to compare different scenarios.

Taking into account phenomena characteristics implied in scenarios would moderate the measurement of the gravity. For its evaluation, it is proposed to quantify the influence of :

- the effect area A concerned with the phenomenon : a disc in case of an explosion, the projection of a plume for the pollutant gas dispersion ;
- the phenomena kinetics K : rapid for explosions, slower for dispersion and fires ;
- capacity of intervention I to master the disaster or to limit its consequences : possible for fire and gas dispersion, but possible only by conception for explosion ;
- potential of domino effect D : emission of projectiles, interlocking of delayed phenomena.

The composed gravity index G could then be a function of parameters only associated with the physical phenomena. Then all scenarios identified could be evaluated and ranked with this gravity index.

With this index, it could be discovered that toxic substances not always generate the highest risk level.

CONCLUSION

This paper emphasises that there is a need to establish a method to measure the risk of an installation by integrating the prevention implemented by the operators, otherwise it will be

difficult to reach the goals of the SEVESO II Directive in all European Country, that are to improve the prevention linked in particular with the management.
It is proposed that the method defines rules to identify scenarios integrating the prevention made by the operators and then evaluate them by taking into account the characteristics of the phenomenon involved.
The application of this method might result in a more consistent risk evaluation and management in the whole EU. The conclusion of the benchmark exercise under the project ASSURANCE (ASSessment of Uncertainties in Risk ANalysis of Chemical Establishments) would certainly justify the development of such a harmonised method.

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